Astrobiology on the Moon. O. Santos, NASA Ames Research Center, MS 239-4, Moffett Field, CA 94035; email: orlando.santos@nasa.gov.

Introduction: Although it may seem at first glance that the role of Astrobiology in lunar science might be relatively small, in fact, the Moon would offer an opportunity to answer several important scientific questions, and would be an excellent test bed for future Mars/outer Solar System technology and life detection methods.

This presentation will review the Astrobiology Roadmap, identify goals and objectives that could be addressed on the Moon, and describe some candidate experiments and technology development.

The Astrobiology Roadmap: The NASA Astrobiology Roadmap [1] was developed in 2002 by a team of 19 scientists from the U.S. government, universities, and private research institutions. The Roadmap was vetted with the external community in an open forum at the 2002 Astrobiology Science Conference, and by inviting comments on the web. The Roadmap is formulated in terms of seven Science Goals; for each goal, specific Science Objectives identify high priority efforts. Below are the Science Goals that could be addressed on the Moon, and examples of experiments addressing each Science Objective.

**Goal 2. Explore for past or present habitable environments, prebiotic chemistry and signs of life elsewhere in our Solar System:** This goal has two objectives: “Mars exploration” and “outer Solar System exploration”.

Lunar studies could support this goal by providing a “blank” non-biological environment for testing. It will be critical to understand the nature of the contaminants inadvertently carried aboard spacecraft and instruments, and how those contaminants interact with a planetary environment.

The Moon would also be a site to search for Martian and early Earth meteorites, that could yield insights into pre-biotic chemistry and early life, and perhaps even evidence for Martian life.

**Goal 3. Understand how life emerges from cosmic and planetary precursors:** The first objective under this goal, “Sources of prebiotic materials and catalysts” could be addressed on the Moon. The Moon represents an ancient, relatively unaltered environment that could yield insights into how prebiotic materials were delivered to Earth and other Solar System bodies.

**Goal 5: Understand the evolutionary mechanisms and environmental limits of life:** This goal is possibly the most relevant for lunar science. The Moon represents a unique test bed, and is currently the only possible locale for long-term biological studies in reduced gravitational fields under space radiation exposure. Studies could be conducted under lunar gravity or, using centrifuges, at Martian gravity levels.

**Objective 5.1. Environment-dependent, molecular evolution in microorganisms:** Microorganisms are essential for human life. They will probably be utilized in advanced life support and bioremediation systems. Experiments on the Moon could help in understanding how gravity and radiation affect microbial evolution.

**Objective 5.2. Co-evolution of microbial communities:** In addition to understanding how individual species evolve, it will be critical to understand the effects of gravity and radiation on mixed, wild-type, microbial communities. Questions addressing microbial Population Genetics, including adaptive changes in allele frequencies, and microbial Ecology, including shifts in species make-up, could be addressed on the Moon.

**Objective 5.3. Biochemical adaptation to extreme environments:** Can Earth organisms survive on the Moon? How long do bacterial spores remain viable on the Moon? These questions are important both from a scientific perspective, and to determine Planetary Protection requirements for future missions to Mars and elsewhere that life could potentially exist.

**Goal 6. Understand the principles that will shape the future of life, both on Earth and beyond:** Objective 6.2. “Adaptation and evolution of life beyond Earth” could be addressed on the Moon. Long term studies to understand how Earth organisms (including mammals) adapt to, and evolve in Lunar and Martian conditions could be conducted on the Moon.

**Goal 7. Determine how to recognize signatures of life on other worlds and on early Earth.** Again, the Moon represents a unique “blank” for testing of life detection technologies. Known quantities of biological materials could be introduced for testing purposes. The Moon also represents a unique vantage point for looking back at the entire Earth, allowing for whole planet testing.